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ABSTRACT

This paper, presented at the Fifth Annual Conference of the Australian Science Education Research Association in 1974, discusses the various strategies for analyzing the data gathered to explore the effect of specific school variables on educational achievement. The discussion centers around the International Association for the Evaluation of Educational Achievement (IEA) strategy of analysis, the use of variance estimates, the use of variation estimates, and the treatment of compound variables. The author contends that none of the strategies is completely satisfactory and calls for further discussion and experimentation. (RWP)

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The effects of the conditions of learning in the schools on educational achievement

John P. Keeves

IEA (International Association for the Evaluation of Educational Achievement) is an international educational research organization.
ACER (Australian Council for Educational Research) is the National Centre for IEA activities in Australia.

The effects of the conditions of learning in the schools on educational achievement

A discussion of the debate between J.S. Coleman and G.F. Peaker at the Harvard-IEA Conference on Educational Achievement at Harvard University, November 1973

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Through the night of doubt and sorrow
Onward goes the pilgrim band
Singing songs of expectation
Marching to the Promised Land.

Translated from the Danish by B.S. Ingemann and quoted by Gilbert Peaker during the period when computer programs were being prepared and some of the issues discussed in this report were being argued out at the IEA data processing unit in Stockholm, in Winter 1971-72.

The International Studies in Evaluation[1] are huge and complex cross-national investigations into the educational achievement of students in general at three stages of schooling, the 10-year-old, the 14-year-old and the terminal secondary school levels, and in seven subject areas: Mathematics, Science, Reading, Literature, Civic Education, English as a foreign language, and French as a foreign language. In November 1973, at Harvard University, a group of educators, sociologists, economists, and statisticians met the team of research workers who had been engaged in these studies to discuss the meaning and relevance of the IEA findings for educational policy and practice and to consider their implications for future cross-national educational and social research. One of the papers presented at the Harvard-IEA Conference was by James S. Coleman of the University of Chicago, on the "Effects of School on Learning: The IEA Findings". In this paper Coleman stated:

> In arguing for measures other than the added explained variance or unique variance, I must point out that I have until very recently used these measures in all my work, and in Equality of Educational Opportunity, we used them. Although I still believe these measures are superior for the present purpose to others currently in use, I think they are not as good as the alternatives I am proposing here. (Coleman, 1973 a : 18).

Peaker, who had helped to guide the IEA analyses during the first phase of the investigations into Mathematics and after a period of some uncertainty had directed the analyses during the second phase of the studies in the six subject areas, replied drawing attention to inconsistencies in Coleman's paper (Peaker, 1973a). Coleman hurriedly modified his original paper and some of the procedures he was proposing, but did not change his basic approach (Coleman, 1973b). Peaker again replied suggesting that the quantity Coleman was proposing as a "measure of equality of educational opportunity" was very dubious while the "measure of the effects of school variables on achievement, that are independent of family background and school type" had indeed been

[1] These studies have been undertaken by the International Association for the Evaluation of Educational Achievement (IEA).

presented in the IEA reports in the squared form (Peaker, 1973b). In the discussions that followed at the Harvard-IEA Conference, the issues were not clarified, with neither Coleman nor Peaker yielding ground. The purpose of this paper is to attempt to raise some of the issues involved, to place them in perspective and to suggest which measures and procedures of analysis are likely to be most useful in future studies.

Over the past decade several major investigations, in addition to the IEA studies, have been undertaken, which have presented evidence on the magnitudes of school effects for student achievement. Peaker has reported the findings of the Plowden National Survey (Peaker, 1967a) and its follow-up study (Peaker, 1971). Coleman was the main author of the report of the Equality of Educational Opportunity Survey (Coleman, 1966). In general, these studies, together with the IEA work, reveal that school variables, as assessed in these inquiries, show little effect on student achievement. The analyses carried out relate the variance existing in the independent variables to that existing in the dependent variable, and the smallness of a reported effect may arise from homogeneity associated with the independent variable (Walker, 1973). Nevertheless, the IEA studies do indicate that school effects are more substantial for the learning of school based subjects such as Foreign Languages and Science and are considerably smaller for the learning of such subjects as Reading (Comber and Keeves, 1973; Thorndike, 1973; Carroll, 1974; Lewis, 1974). These findings are disappointing for those who argue the need to improve the quality of schooling and who attempt to identify factors which contribute to disparities in educational achievement among students in different school and societal situations. If the important school factors could be determined and the magnitudes of their effects assessed, then a case could be argued for the allocation of resources to improve the conditions of schooling for those students whose level of achievement in education is lower than might be expected.

Following the publication of the report, Equality of Educational Opportunity with its evidence suggesting that there was relatively little that schools could do to raise the level of performance of students in the United States, attempts were made to reanalyse the data and to present the findings in alternative ways that would assess more accurately the contributions of the schools. One important such investigation, A Study of Our Nation's Schools by Mayeske (1969), suggested that alternative techniques for the analysis of the data yielded somewhat different findings. This procedure showed that the school shared its effects in part with the home, but it was not very successful in identifying school factors that contributed markedly to student achievement. Others have criticized the techniques used by Coleman and his co-workers (for example, Bowles and Levin, 1968; Dyer, 1969). Consequently the recommendations made by Coleman for superior measures and methods of analysis are clearly based on a sound knowledge of the complexity of the task and an awareness of the need for the use of procedures that are free, as far as is possible, from the criticisms raised.

While prolonged consideration of methodological issues may sometimes appear an unrewarding and barren task, it is nevertheless an important one. Guidance is needed for attempts to reduce the inequalities known to exist in educational opportunity. Programs of compensatory education are required and where possible they should be based on research evidence. Consequently, it is desirable that the analytical procedures employed to examine research data to provide this evidence should be powerful and unambiguous.

The IEA Strategy of Analysis

The IEA investigations carried out so far have been cross-sectional studies in which inferences have been made about the influence of home and school factors from evidence collected at one point in time. Longitudinal studies (for example, Peaker, 1971; Keeves, 1972) are free from some of the criticisms levelled at cross-sectional inquiries, but they are more time-consuming, costly, and more technically complex. Peaker (1973 b : 4) has pointed out that in the absence of pre-test data assessing student initial achievement, it is necessary to simulate the pre-test by using information about the student's home circumstances and the type of school he attends or the type of course or program he is engaged in. Thus in the IEA analyses the variables examined for their contributions to educational achievement were grouped into four blocks according to their type and the sequence in which they were believed to effect student achievement. The blocks were defined roughly as follows:

Block 1. Home and Student Background, comprising Home Circumstances, Age, and Sex;

Block 2. Type of School and Type of Course or Program, where there was sufficient differentiation within a sample for such variables to be formed;

Block 3. Learning Conditions in the School and Grade;

Block 4. "Kindred" Variables, so called because they were contemporaneous with the criterion in time, including such measures as school motivation and interest in the subject.

Furthermore there was the criterion variable which was a measure of student achievement.

A few comments are needed about some of these measures because misunderstandings have occurred. First, the Block 4 variables cannot be considered rightly as determinants of achievement, since they are also influenced by achievement. In the development of a recursive causal model it is necessary that they should be excluded from consideration. Secondly, the Block 3 variables are those of greatest interest. In general, they represent factors which can be modified to influence student achievement.

In an age sample the variable Grade, while indicating exposure to learning, may be related to the ability of the student or to promotion policies in schools of different types. Thirdly, the Block 2 variables concerned with the Type of School the student attends and the Type of Course he is following are related in some countries to the performance of the student prior to the time he comes under survey. However, a careful examination of how these variables are defined shows that in some countries these measures are clearly linked with the home background of the student, sex, the region in which the school is located and the students' perceptions of the courses they are taking at school. Many of these factors are not necessarily related to the prior performance of the student. Coleman rightly points out using Peaker's yacht handicap analogy (see Comber and Keeves, 1973: 194-6) that yachts with the greatest handicap also have better crews, or in school terms the schools holding the more able students tend to provide better conditions for learning (Coleman, 1973a: 10). In addition, schools for students from more favoured homes, or from more affluent regions, or for boys, may provide better learning conditions than do schools for students less fortunately placed. Fourthly, the variables in Block 1 cannot be seen solely as measures of the home circumstances of the students, since sex and age are also included in this block. These variables are, however, fixed and not subject to change.

In order to examine the interrelations between the variables in the first three blocks and student achievement and in the absence of information on the student's initial level of skill, it is helpful to develop a simple causal path model. Coleman (1973a: 11) makes clear that he is "not an advocate of path analysis", but he does use such a path diagram very effectively to clarify certain issues in the analysis of the data. In a cross-sectional study it may be argued that the Block 1 variables, Home and Student Background, influence the Type of School the student attends and the Type of Course or Program that he follows (The Block 2 variables).

Furthermore, both the Block 1 and Block 2 variables influence the Learning Conditions in the School (Block 3 variables) and the variables in all three blocks directly and indirectly influence student achievement. The network of interrelationships among the three blocks of variables and Achievement may be represented by the causal path model shown in Figure 1.

The estimation of the magnitudes of the interrelations among the blocks of variables and their components in such a causal model is undertaken by regression analysis. Thus the use of the causal path model is consistent with the regression analysis procedures used in most of the studies that have been referred to. The same model was used in the IEA analyses for the examination of data where both schools and students were the units of analysis, although the variables included within the blocks differed slightly in their composition from subject to subject, from population to population, and from the between school analyses to the between student analyses. Underlying this causal model is a line of reasoning that earlier events in the life of the child influence later events, and the path diagram makes explicit the causal sequence employed to study school effects and their dependence on the home and student background measures. While it may be possible to challenge some of the measures included in the different blocks, it is difficult to quarrel with this causal model and Coleman (1973a: 11) does not do so, nor does he question the use of regression procedures. The debate between Peaker and Coleman is within the framework of regression analysis and is directed towards the choice of statistical measures to express the relationships assumed to exist and the techniques employed to separate out and assess hypothesized effects. The discussion focusses on two procedures (1) the use of variance estimates and (2) accounting for variation in scores.

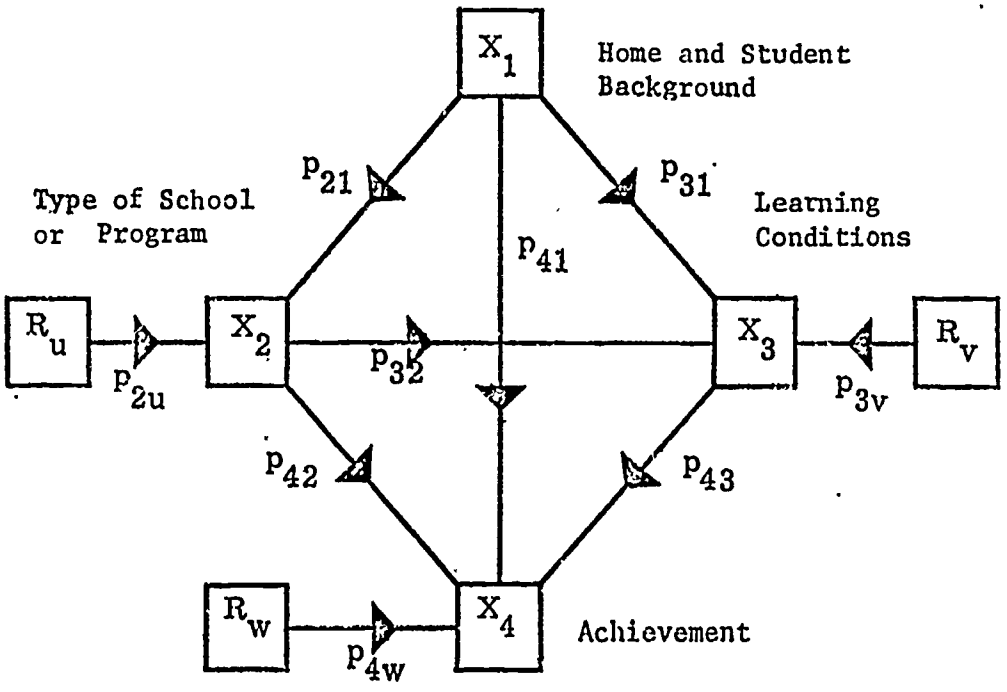

Figure 1. A Path Diagram for the Causal Model used in the IEA Studies.

where X_1 denotes the Home and Student Background Variable
X_2 denotes the Type of School or Program Variable
X_3 denotes the Learning Condition Variable
X_4 denotes the Achievement Outcomes
R_u denotes the residual variables for Type of School or Program
R_v denotes the residual variables for Learning Conditions
R_w denotes the residual variables for Achievement

The Use of Variance Estimates

The major educational studies carried out by Peaker, Coleman and others have examined the effects of individual factors or collections of factors on student achievement using variance estimates in which the contribution of the variable or collection of variables in accounting for the variance of the achievement test scores is assessed. Peaker (1967a) in the report of the Plowden National Survey estimated the contributions of individual variables to explaining the variance of the achievement test scores using the product of the zero-order correlation coefficient (r) with the standardized partial regression coefficient (b) (Guilford, 1956). Darlington (1968) has criticized the use of this procedure since for suppressor variables the product is negative and a negative contribution to explained variance does not appear to be meaningful (see Ward, 1969; Duncan, 1970).

An alternative measure that is clearly appropriate to use where the predictor variables are orthogonal or where all variables can be ordered in a clearly defined temporal sequence is the square of the semi-partial correlation coefficient at each step in the analysis. This measure is the variance added at each step of the regression analysis and was used in the report of the Survey of Equality of Educational Opportunity (Coleman, 1966).

In the reanalysis of this data reported by Mayeske (1969), the estimates of variance accounted for were separated into unique and joint contributions following a procedure which has been stated more fully by Wisler (1969) and Mood (1971). This technique was advanced earlier by Newton and Spurrell (1967) and was employed also by Peaker (1971) in the report of the Plowden Follow-up study. Peaker (1967b) noted that under certain circumstances the joint contributions to variance explained could be negative, a shortcoming of this measure that had also been recognized by Mood (1971). The conditions under which negative joint effects arise

have been considered in detail by Beaton (1973). They are linked with effects that are similar in kind to suppressor relationships. The unique contribution to the variance accounted for is the square of the standardized partial regression coefficient (b) multiplied by the standard deviation of the residual (s) at the penultimate stage. This measure ($b^2 s^2$, sometimes recorded as $b^2/_c$, where c is the term in the diagonal of the matrix of the regression coefficients at the ultimate stage) is a lower bound for the variance contribution of the variable and provides some assessment of its separate contribution and thus of its relative importance.

The use of variance measures permits the effects of individual variables to be combined by simple addition or subtraction in order to obtain estimates of the unique and joint contributions of blocks of variables and where required to obtain the independent and total effects of the collections of variables in the blocks.

In general in the IEA reports variance estimates have been used. It was clearly necessary to combine the effects of variables particularly in Block 3, where the contributions of individual variables assessing the effects of the different learning conditions in the schools were small. The increments in variance associated with the inclusion of each block of variables in the regression equation have been presented in the reports to provide evidence on the relative importance of the different factors incorporated within each block. Furthermore, in the Science report (Comber and Keeves, 1973) it was argued that there was substantial overlap between the Block 2 variables, Type of School and Type of Course or Program, and the Block 3 variables, Learning Conditions in the Schools. Consequently, to assess accurately the school effects it was necessary to combine the variance estimates for these two blocks and to express them in terms of unique and joint contributions.

It is important to note that cases arise in the IEA reports, where the joint contributions of the variables in Blocks 2 and 3 are negative, casting some doubt on the Newton and Spurrell method of assessing the effects of both individual variables and blocks of variables since a term involving a negative contribution to the total variance gives rise to problems of interpretation. A further shortcoming of the use of variance estimates of the effects of variables is that insufficient attention is sometimes given to the direction in which factors are working. Where suppressor relationships are involved they are not always exposed for scrutiny. Some discussants of the IEA results have been confused by effects of this kind which occur in the evidence presented (for example Bloom, 1973) and as a result have misinterpreted the direction in which factors are operating. Not only are such suppressor relationships sometimes difficult to interpret, but they may not always give proper insight if weights are taken at face value. The problem arises from the interdependence among the variables in the regression equation in such a situation, and the variables should not be interpreted as if they were independent factors (see Van de Geer, 1971: 126-127).

The Use of Variation Estimates

Coleman (1973a) argues the case for the use of alternative measures that have a direct operational meaning in terms of predicting differences in scores. Variance measures involve the squares of the differences, variation measures are based on the unsquared differences in the scores and therefore also encompass the notion of direction as well as magnitude. The emphasis is on the capacity of a variable or a block of variables to predict variation in the achievement test scores rather than accounting for the variance of the test scores. Coleman directs attention to three such measures which respectively assess the contributions to variation of:

1. The effects of Learning Condition variables through which Home Background and Type of School variables are acting.

2. The effects of Learning Condition variables which are independent of the effects of Home Background and Type of School variables.

3. The total direct effect of the Learning Condition variables.

If we consider the Home, School and Learning Condition blocks of variables as specified in the causal model presented in Figure 1, the third measure is given by the standardized partial regression coefficient for Achievement regressed on the Learning Condition variables controlled for the Home and Student Background variables and the Type of School or Type of Program variables ($b_{43.21}$). This quantity is reported for individual variables in two of the reports (Purves, 1973; Thorndike, 1973) but in the Science report (Comber and Keeves, 1973) it is only presented for those variables where the pattern of results suggests that a factor is acting significantly and consistently across countries for a given population. This quantity was not, however, calculated or reported for the learning condition variables as a block.

The second measure as Coleman (1973b) showed is given by $b_{43.12} \cdot s_{3.12}$ or $b_{43.12} \cdot \sqrt{1 - R^2_{3.12}}$. This measure is the square root of the unique contribution of a block of variables, and some evidence on this measure was presented in square form in the reports. A more detailed treatment will be presented in square form in the technical report of the IEA studies (Peaker, 1974).

The first measure is given by the product $b_{43.21} \cdot b_{3.21}$, where $b_{3.21}$ is the standardized regression coefficient for Block 3 variables regressed on a compound variable for Block 2 and Block 1.

Coleman (1973a) presents some computational formulae for calculating these coefficients when only indices for individual variables and multiple correlation coefficients have been provided by computer programs. It

would appear that what Coleman is really suggesting is equivalent to an examination of relationships between compound, but unobserved, variables for the hypothesized blocks using path analysis techniques. The calculation of direct and indirect causal path effects for the causal path model presented in Figure 1 would appear to be largely equivalent to the calculation of the measures he has proposed. He has suggested in passing that regression weights could be employed in the formation of a new compound variable (Coleman, 1973a: 27), but since this is not the only way of proceeding, this problem will be considered separately later in this paper.

Although variance estimates allow measures of the effects of a set of variables to be obtained readily from data on the effects of single variables, Coleman argues for the use of variation estimates on the grounds that these latter measures are more easily interpreted having an explicit meaning in terms of score differences. Moreover, since the results are not reported in the square form, they are not only directly comparable from one set of standardized variables to another, but they also lead to greater optimism about the relative size of the effects of the school variables. The thrust of Coleman's papers (1973a, 1973b) is the desirability of using variation measures, regression weights and path coefficients or their equivalent, instead of variance measures to examine the relative effects of individual variables or collections of variables.

A Measure of Equality of Educational Opportunity

Coleman (1973a: 33-34) has proposed, using measures involving estimates of the effects of blocks of variables on the variation in the achievement test scores, an index of "equality of educational opportunity". Two of the three measures discussed above are employed. The second measure assessing the effects of learning condition variables which are independent of the effects of home and school type may be regarded as the actual influence

of the schools in equalizing educational opportunity. The third measure gives the total direct effect of the learning condition variables and may be thought of as the capacity that the schools have for equalizing educational opportunity if learning conditions were distributed without regard to home and student backgrounds and school type. The proportion of the total direct effect of the schools which is distributed independently of home and school resources can be considered as a measure of equality of educational opportunity. Peaker (1973b: 5) draws attention to the fact that this ratio is:

$$E = \frac{\text{Effect of schools independent of home and school type}}{\text{Total direct effect of the schools}}$$

$$= \frac{b_{43.12} \cdot s_{3.12}}{b_{43.12}}$$

$$= s_{3.12}$$

Further, since this ratio is equal to the residual standard deviation for the learning condition measures after inclusion of the home and school type measures in the regression equation Peaker suggests:

> To the writer, at any rate, it seems reasonable to conclude that while the case may be somewhat altered when surrogates are used for the pre-test it is not altered very much, and that the ratio does not tell us a great deal about equality of opportunity (Peaker, 1973b: 6).

To support this view he uses data from The Plowden Children Four Years Later (Peaker, 1971) and argues that such a measure while superficially attractive may present problems of interpretation. In discussion neither Coleman nor Peaker yielded to the views of the other. It would appear necessary to test this ratio with data from a variety of sources to assess the usefulness of this measure of equality of educational opportunity.

The Treatment of Compound Variables

Some of the issues associated with the combination of observed variables to form compound unobserved variables have been examined by Hauser and Goldberger (1971). Four approaches have been employed in recent studies for dealing with these problems; these use (1) principal component analysis, (2) restricted maximum likelihood factor analysis, (3) regression analysis, and (4) canonical analysis. An alternative approach has been advanced by Wold (1974) which uses non-linear iterative partial least squares modelling (5).

Principal Component Analysis

1. In the discussions following the presentation of the paper by Coleman at the Harvard-IEA Conference the use of weights derived from a principal component analysis was suggested for the formation of a compound variable. This strategy was used by Keeves (1972). A similar approach involving the use of Varimax Rotation and Factor Analysis had been used by Coleman (1966) and Peaker (1967a). These procedures are appropriate where the variables can be assumed to be measured without error, and where one or more unidimensional unmeasured factors are associated with the measured variables.

2. Restricted Maximum Likelihood Factor Analysis

   This procedure has been advanced by Jöreskog (1970), and developed by Hauser and Goldberger (1971). It involves the use of confirmatory factor analysis. It is appropriate where the variables are measured with error and a correction is applied for such errors. Since certain zero factor loadings are necessarily specified in advance, the unmeasured factors must be readily identified. This approach has been used recently by Williams (1973).

3. Regression Analysis

   Tukey (undated) advanced the idea of using rosettes as carriers of regression in which the measured variables were combined using regression weights to form the unmeasured compound variable. The regression weights can be calculated with all measured variables appearing in the compounds included in the regression analysis or

with only those variables incorporated in a specific compound being included. This procedure makes no correction for attenuation, nor does it assume that a unidimensional factor lies beneath the compound measure so formed. Furthermore it serves to maximize the relationship between the measured variables and the criterion in the formation of the compound. This procedure was employed in part in the IEA analyses, and Coleman (1973a) proposes an extension of this principle to form compound measures associated with the predictor blocks of variables.

Since the reanalysis of data is tedious after each new compound variable is created Coleman (1973a Appendix) presents two procedures by which path coefficients can be calculated using data normally available from regression analysis results.

4. Canonical Analysis

Cooley and Lohnes (1974) have developed procedures by which analyses might be carried out in situations where several predictors are compounded into blocks and where several criterion measures are used. Traditionally, in canonical analysis the interpretation of the canonical factors has been based on the standardized weights, but Cooley and Lohnes (1971) adopted a procedure in which the canonical factor structure was defined by the correlations between the original observed variables and the derived canonical variables. This provides a more meaningful interpretation of the canonical factors, while the canonical weights tell the relative contributions of each original variable to the canonical factors. In addition, Cooley and Lohnes (1974) extended the use of the redundancy measure in order to examine the commonality between the blocks of variables and they illustrated the use of these procedures with several sets of data.

5. NIPALS (Non-iterative Partial Least Squares) Modelling

In general terms, the NIPALS approach leads to the construction of non-linear models by linear methods. Following the specification of the model, with due regard to its intended use, the unknown parameters

and latent variables are estimated using iterative ordinary least squares regression procedures. Wold (1974) claims several advantages for this approach, not the least of which is the economy of assumptions, that often make the NIPALS model more general than alternative models. As yet this approach does not appear to have been applied extensively in the analysis of educational and sociological data.

Summary and Conclusions

The results of the surveys conducted by IEA and by the United States Office of Education in the study of Equality of Educational Opportunity have indicated that to examine the effects of specific school variables using the data collected in surveys is at best a hazardous procedure. Experience suggests that it is more effective to examine clusters of related school variables since each individual variable has only a small effect. Several procedures have been suggested for combining together specific measures to form an unmeasured composite whose overall impact can be more accurately assessed. Which procedure is to be employed must depend on the nature of the specific measures being combined and the nature of the model which has been developed and is being examined with the data collected. However, in the IEA studies where a model was developed consisting of three blocks: Home and Student Background, Type of School or Program, Learning Conditions in the School, and with Achievement as the criterion variable, it would appear most appropriate to form compound measures based on regression weights.

Nevertheless, it would appear to be appropriate for a series of analyses to be carried out on a set of data to explore the use of the first four techniques discussed above. Each no doubt has its strengths and its limitations and only by examining in detail the alternative procedures available can issues associated with the formation of unmeasured variables be resolved. The maximum likelihood approach and related techniques would, however, appear to be currently growing in favour. The usefulness

of NIPALS modelling should also be explored with data from educational and sociological studies, since without illustrative analyses it is difficult to assess the value of this promising approach.

The use of regression procedures in the analysis of the IEA data was unchallenged in this debate; what was questioned by Coleman was the most meaningful way in which relevant evidence could be extracted from the analyses. Earlier Cronbach (1957) advocated a convergence of the procedures used by the experimenter in psychology with those employed by the correlational psychologist in the examination of evidence in scientific psychology. Since then regression analysis, in particular, and canonical analysis have been so developed that they provide in part a convergence of techniques that is consistent with the merging of approaches which Cronbach sought. Nevertheless, there is still some lack of agreement among analysts as to whether variance estimates or regression weights and variation estimates should be employed in the presentation and interpretation of the findings.

Those experimenters who have been schooled in the Fisherian tradition of analysis of variance would appear to prefer to express the evidence in terms of variance effects and increments to variance explained. However, econometricians, who have had greater experience with path analysis techniques, advocate the use of path coefficients, regression weights and their like. Coleman (1973a, 1973b) in his discussion of the analyses of the IEA data has proposed a shift from the use of variance measures to variation measures and regression weights although it should be noted he does not advocate the use of path analysis techniques. Peaker would seem to suggest that the difference in form between the square and the unsquared term is largely trivial, and in interpreting the findings it is possible to shift from one form to the other as is most appropriate. Coleman argues that the virtue of the variation measures "is that the numbers have a direct operational meaning in terms of predicted differences in scores under particular hypothetical experiments" (Coleman, 1973b: 8) and that "the use of the squared rather than the unsquared form leads to an

unwarranted pessimism about the size of the effects" (Coleman, 1973: 31). If space allows in the presentation of results from studies in the immediate future it would appear desirable to use both forms and to draw inferences from both. Peaker (1971) has used such an approach very successfully in reporting the results of the study of The Plowden Children Four Years Later. But it is only by the use of both sets of measures in ways in which comparisons are possible, that the question of their relative usefulness will be resolved.

A further innovation suggested by Coleman is an index of equality of educational opportunity. The development of a measure to assess this concept could serve an extremely useful purpose in both cross-national and cross-regional studies. However, it is questionable whether the quantity that Coleman is proposing when denuded of its verbal embellishments does actually provide such a measure.

IEA owes a substantial debt to both authors. Gilbert Peaker has for nearly a decade steered the IEA analyses between the Scylla of superficiality and the Charybdis of cost in extracting every possible result from a plethora of data. In the dark days of 1965 he suggested an alternative approach for the analysis of the data in the Mathematics Study and again in late 1971 and early 1972, when other helpers had failed, he guided day by day from a distance of many miles the analyses which were carried out. On the other hand James Coleman visited the Stockholm data processing unit only for a few brief hours and from the wisdom and experience gained in examining the data collected in the Equality of Educational Opportunity Survey he gave advice on two critical problems that greatly assisted the work that followed and the results that have been presented.

The debate between Peaker and Coleman at the Harvard-IEA Conference could well advance very substantially the strategies of analysis employed in examining the data gathered not only in future large scale surveys but also in large scale experimental studies.

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